Title: UNIT-LAYER POST-PROCESSING CATALYST CHEMICAL-VAPOR-DEPOSITION APPARATUS AND ITS FILM FORMING METHOD
Inventor: Makiko KITAZOE et al
Appln No.: New Application
Atty. Docket No.: 101136-00131

FIG.1

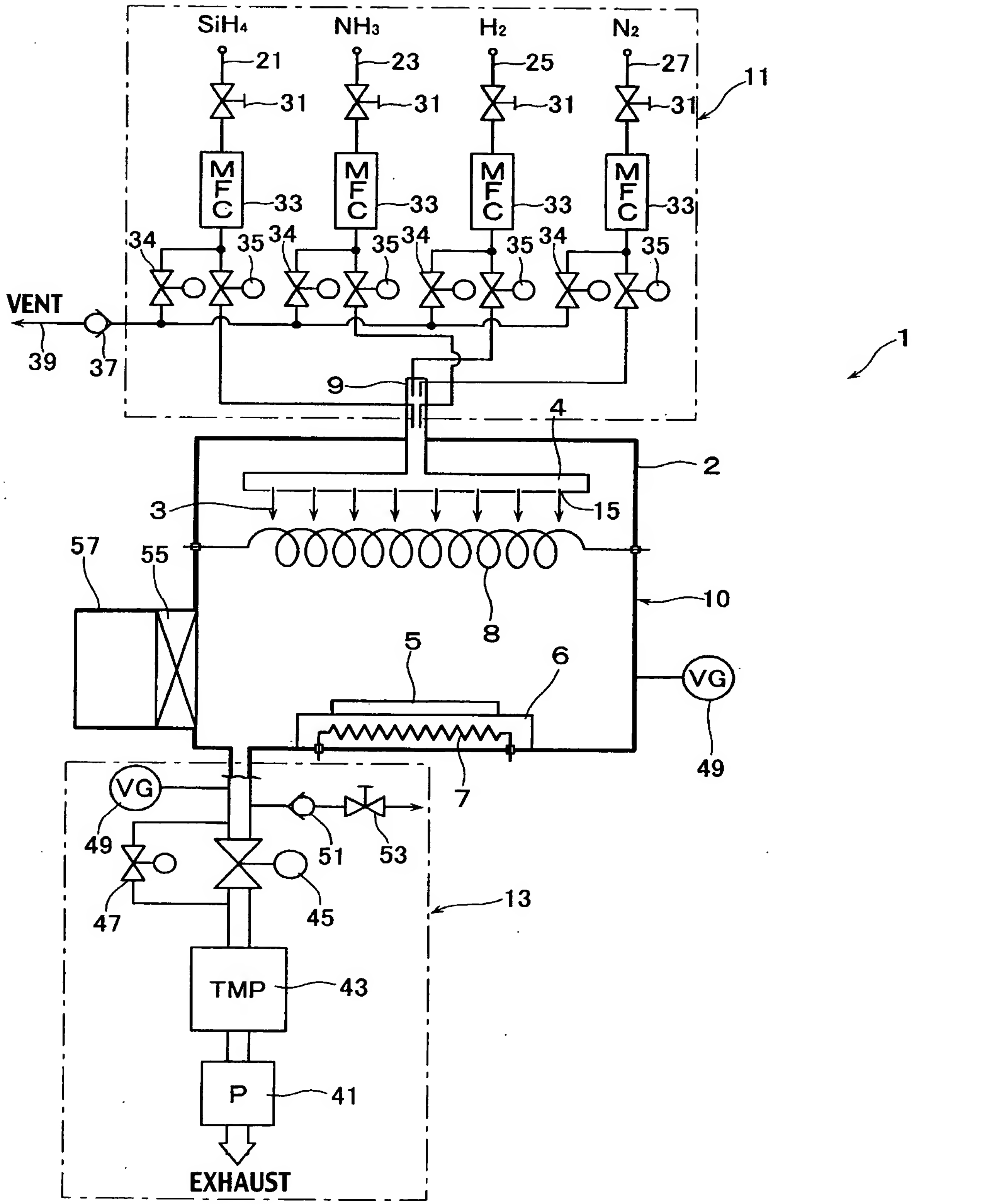


FIG.2

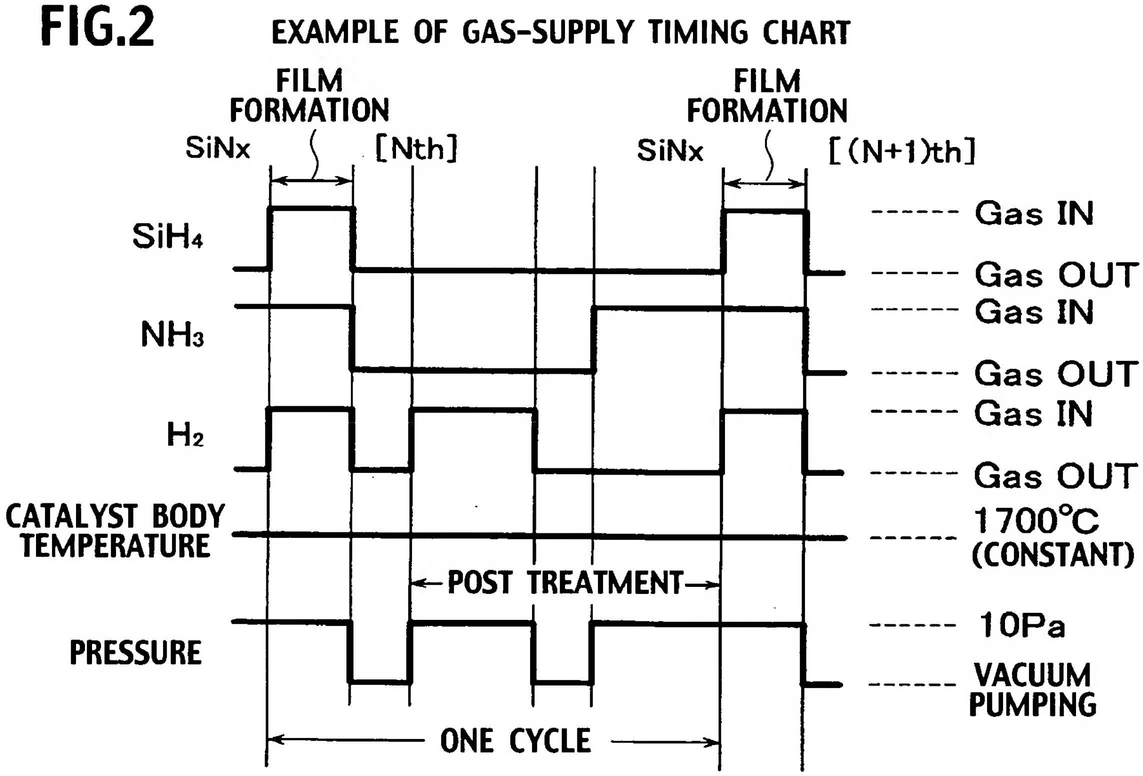

EXAMPLE OF GAS-SUPPLY TIMING CHART
FILM FORMATION
SiNx
[Nth]
FILM FORMATION
SiNx
[(N+1)th]
SiH4
NH3
H2
CATALYST BODY TEMPERATURE
PRESSURE
Gas IN
Gas OUT
Gas IN
Gas OUT
Gas IN
Gas OUT
1700°C (CONSTANT)
POST TREATMENT
10Pa
VACUUM PUMPING
ONE CYCLE

FIG.3

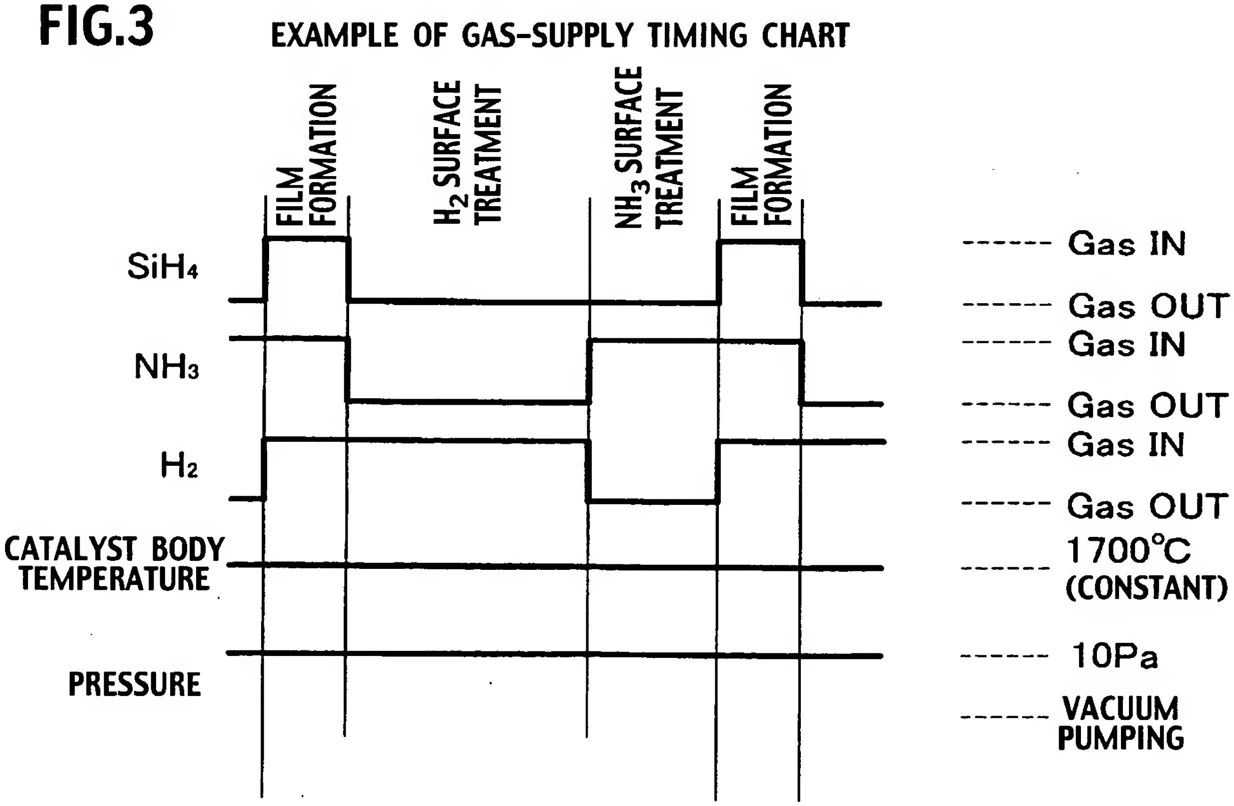

EXAMPLE OF GAS-SUPPLY TIMING CHART
FILM FORMATION
H2 SURFACE TREATMENT
NH3 SURFACE TREATMENT
FILM FORMATION
SiH4
NH3
H2
CATALYST BODY TEMPERATURE
PRESSURE
Gas IN
Gas OUT
Gas IN
Gas OUT
Gas IN
Gas OUT
1700°C (CONSTANT)
10Pa
VACUUM PUMPING

FIG.4

EXAMPLE OF GAS-SUPPLY TIMING CHART

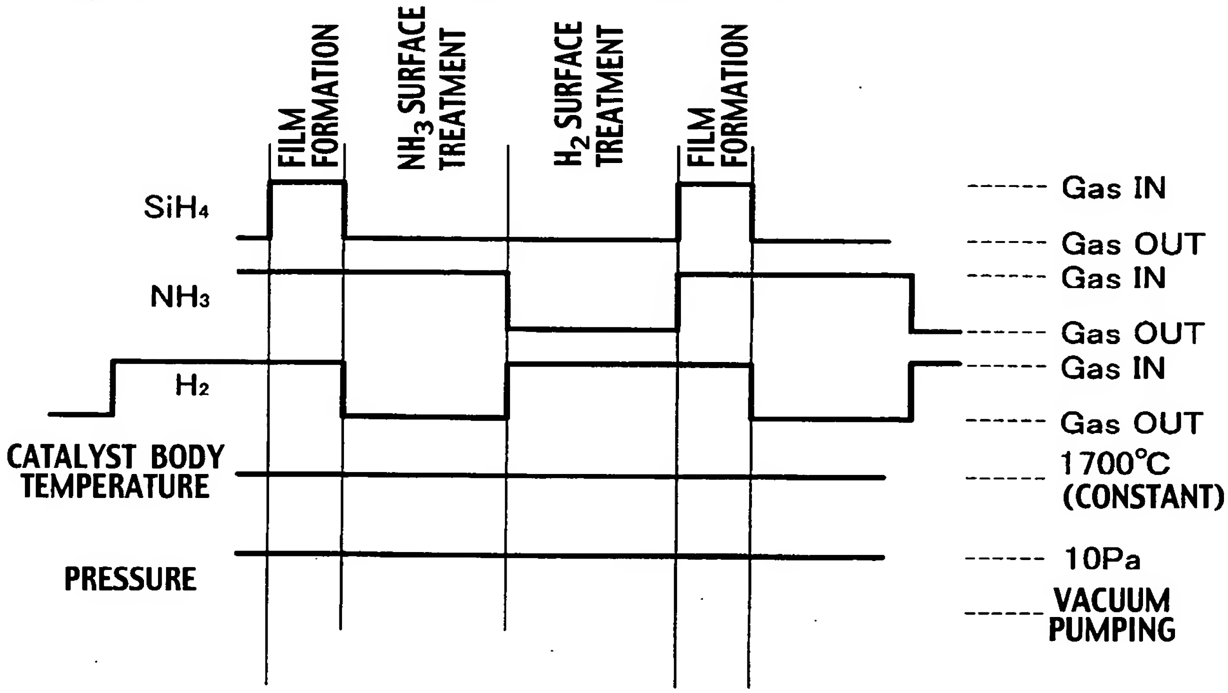


FIG.5

EXAMPLE OF GAS-SUPPLY TIMING CHART

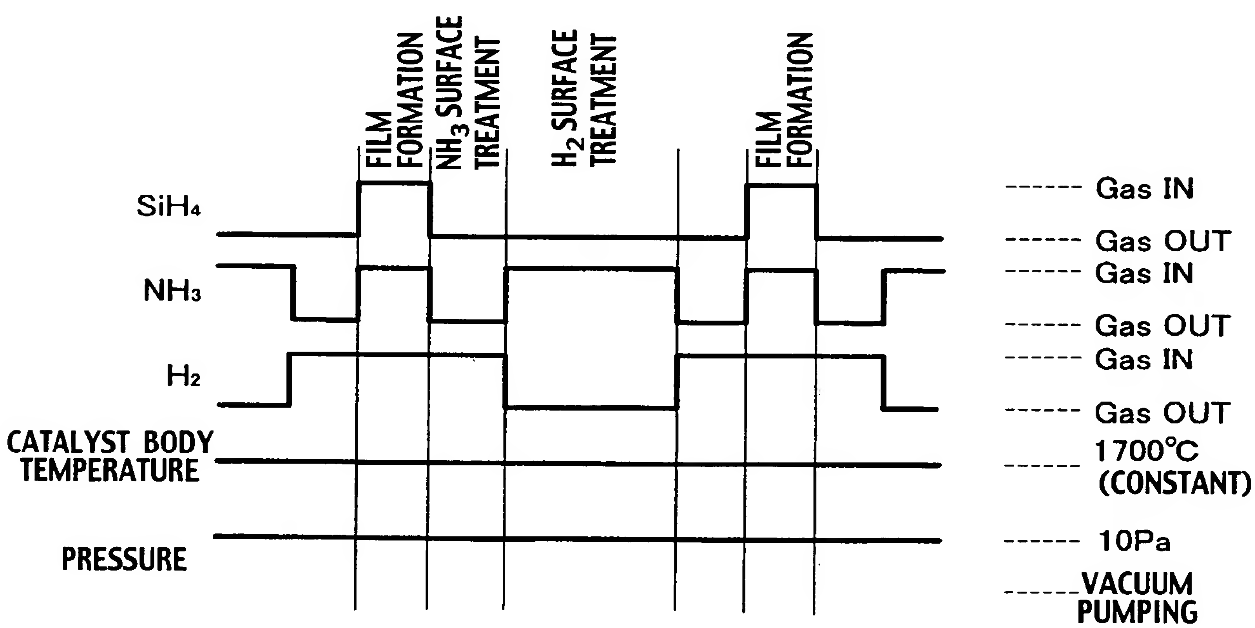


FIG.6

EXAMPLE OF GAS-SUPPLY TIMING CHART

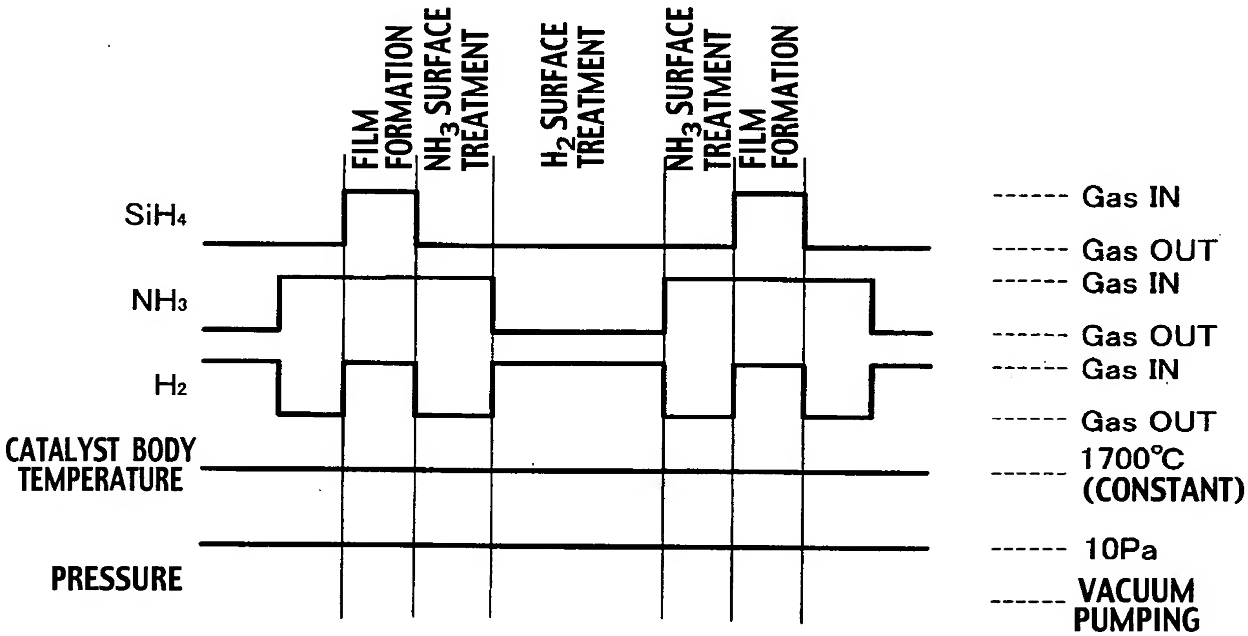


FIG.7

EXAMPLE OF GAS-SUPPLY TIMING CHART

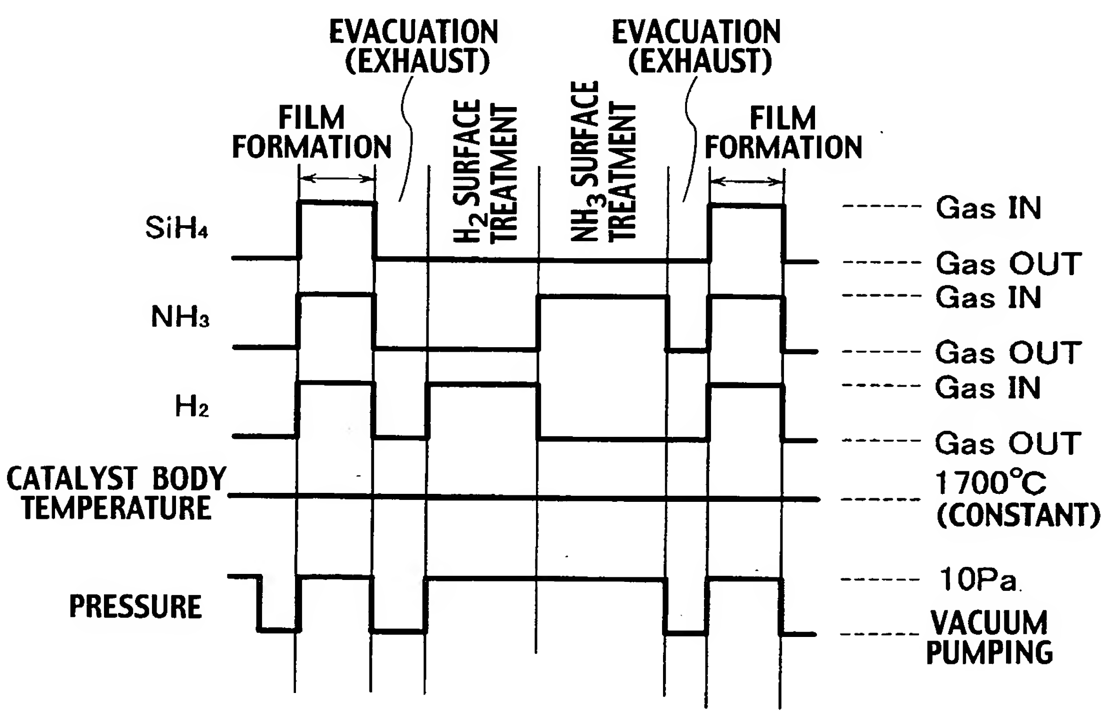


FIG.8

Cat-CVD STEP COVERAGE BY $SiH_4/NH_3/H_2$

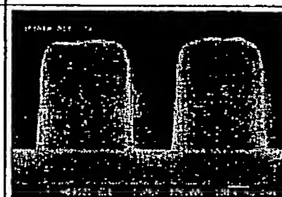
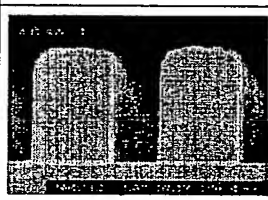
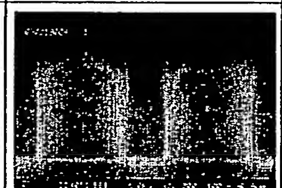
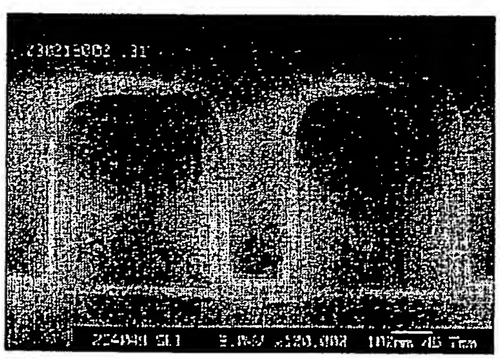
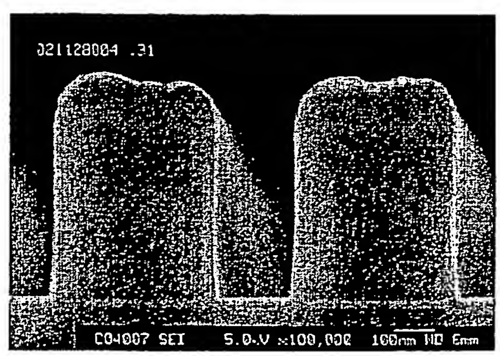
	NH_3 FLOW RATE [sccm] *($SiH_4/NH_3/H_2$=[7/10/(VARIABLE)]sccm, 10Pa)*			
	0	10	15	30
300°C	—		—	—
100°C				

FIG.9

COMPARISON BETWEEN ADDITIVE GASES OF COVERAGE



$SiH_4/NH_3/H_2$



$SiH_4/NH_3/N_2$

BEST AVAILABLE COPY

FIG.10

IN-SITU POST TREATMENT PRESSURE DEPENDENCY

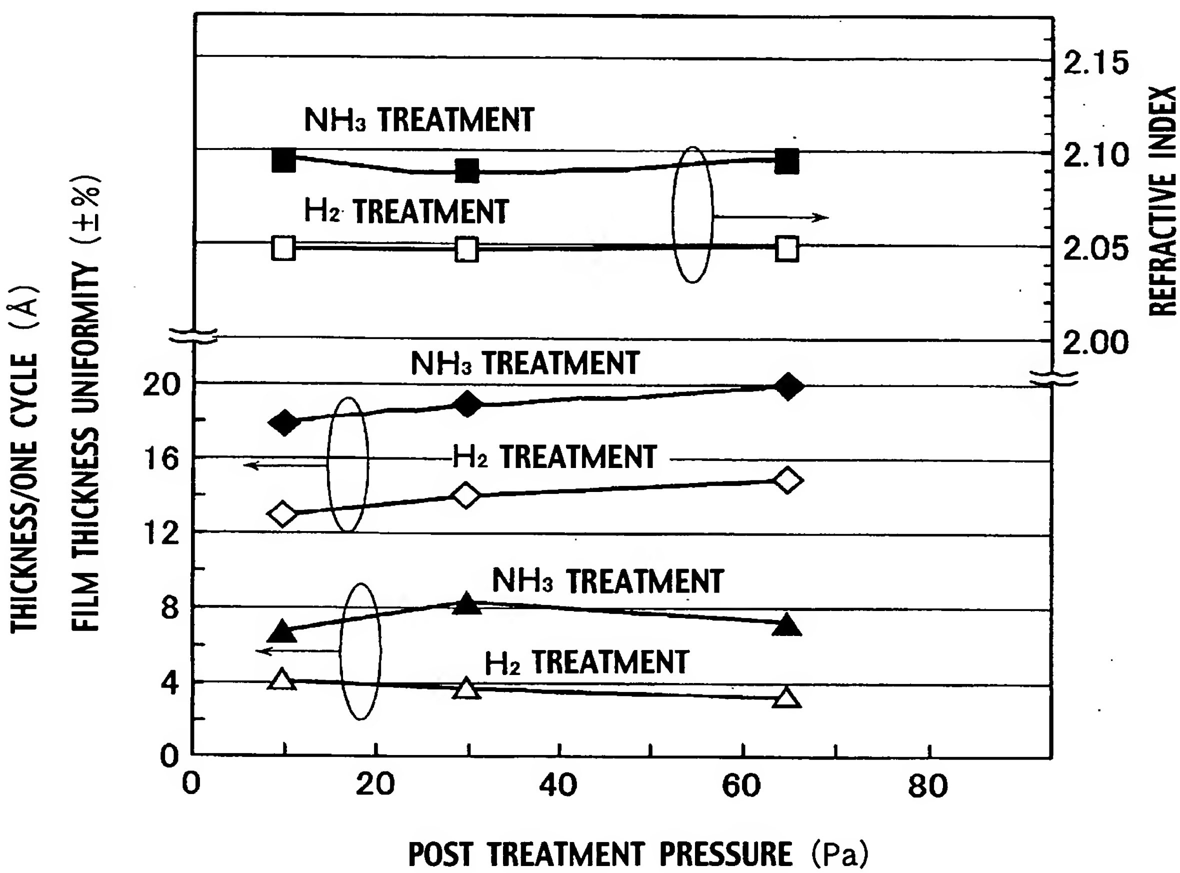


FIG.11

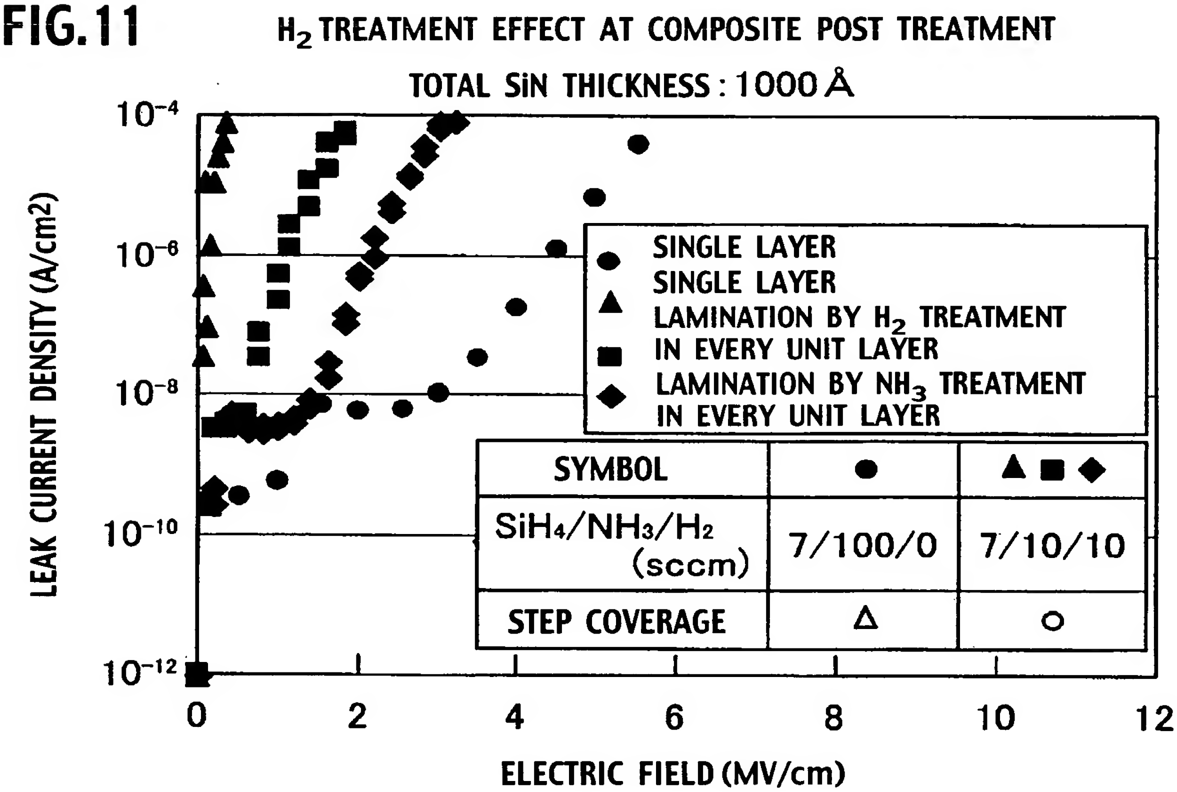

H_2 TREATMENT EFFECT AT COMPOSITE POST TREATMENT
TOTAL SiN THICKNESS : 1000 Å
LEAK CURRENT DENSITY (A/cm2)
10^{-4}
10^{-6}
10^{-8}
10^{-10}
10^{-12}
0
2
4
6
8
10
12
ELECTRIC FIELD (MV/cm)
SINGLE LAYER
SINGLE LAYER
LAMINATION BY H_2 TREATMENT
IN EVERY UNIT LAYER
LAMINATION BY NH_3 TREATMENT
IN EVERY UNIT LAYER
SYMBOL
$SiH_4/NH_3/H_2$ (sccm)
7/100/0
7/10/10
STEP COVERAGE
△
○

FIG.12

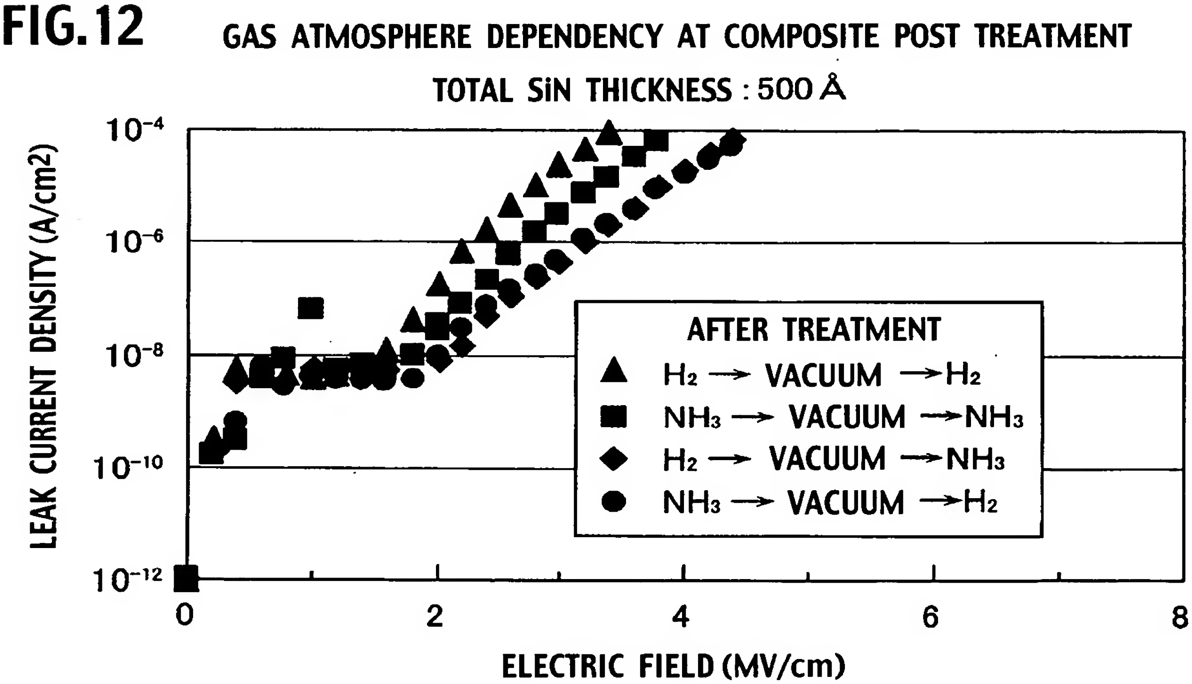

GAS ATMOSPHERE DEPENDENCY AT COMPOSITE POST TREATMENT
TOTAL SiN THICKNESS : 500 Å
LEAK CURRENT DENSITY (A/cm2)
10^{-4}
10^{-6}
10^{-8}
10^{-10}
10^{-12}
0
2
4
6
8
ELECTRIC FIELD (MV/cm)
AFTER TREATMENT
H_2 → VACUUM → H_2
NH_3 → VACUUM → NH_3
H_2 → VACUUM → NH_3
NH_3 → VACUUM → H_2

FIG.13 UNIT-FILM THICKNESS DEPENDENCY OF LAYERED CAT-SiN FILM

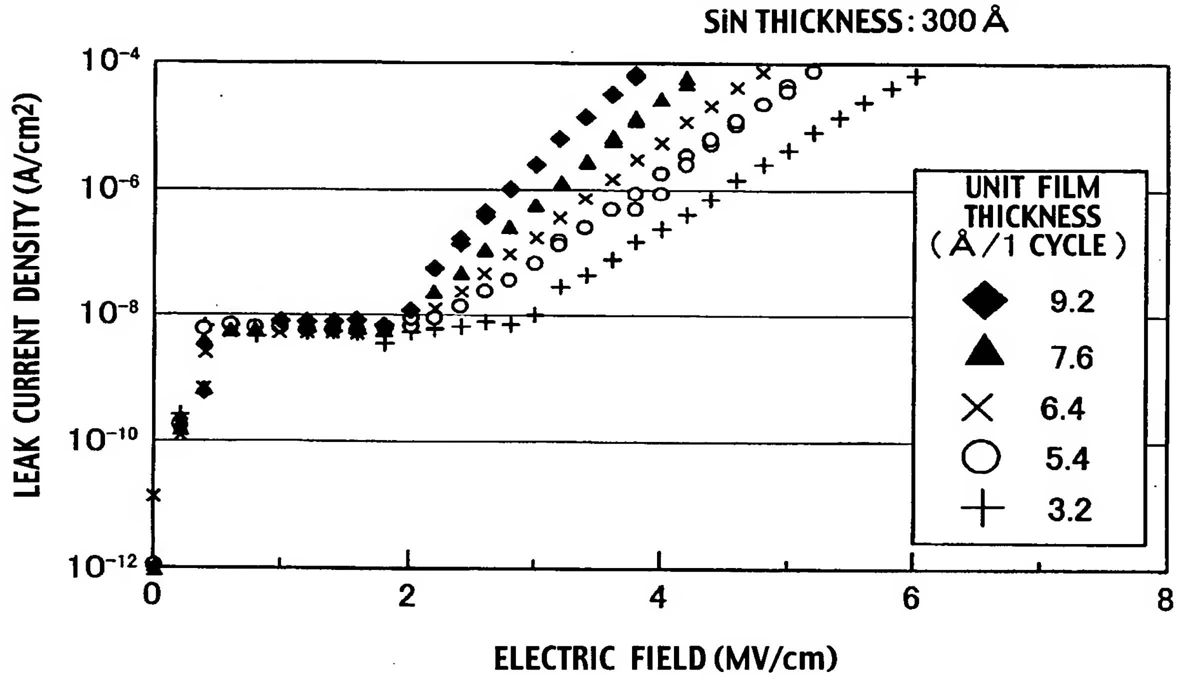
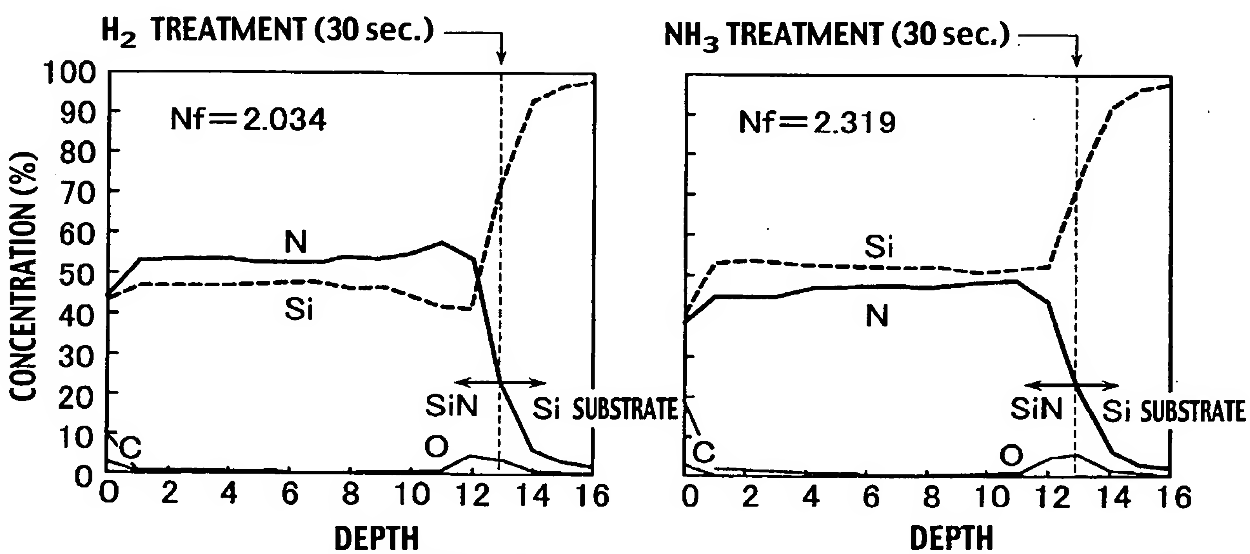


FIG.14 COMPOSITION RATIO OF SiN FILM BY NH_3 RESTRAINED $SiH_4/NH_3/H_2$



(a) ON H_2 PRECEDENT INTRODUCTION Si SUBSTRATE

(b) ON NH_3 PRECEDENT INTRODUCTION Si SUBSTRATE

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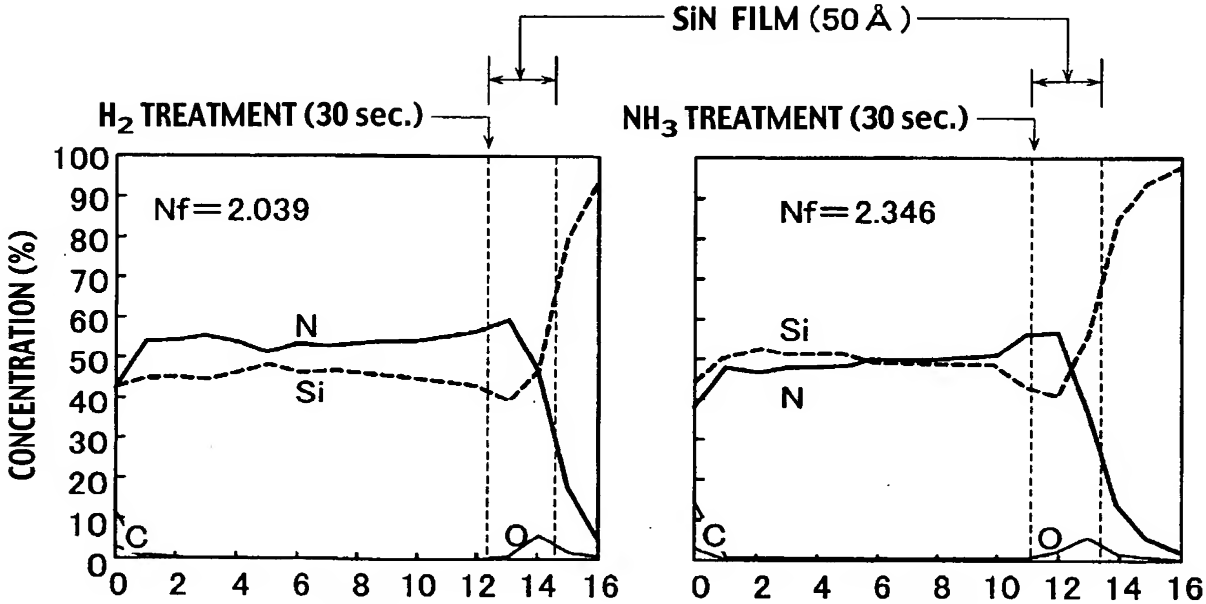
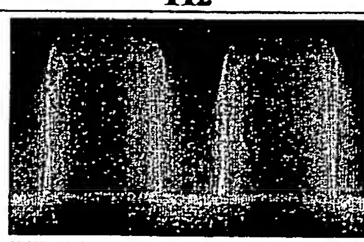
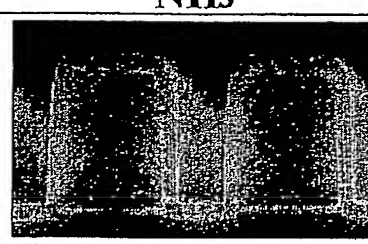
FIG. 15 COMPOSITION RATIO OF SiN FILMS BY NH_3 RESTRAINED $SiH_4/NH_3/H_2$



(a) ON H_2 PRECEDENT INTRODUCTION SiNx (b) ON NH_3 PRECEDENT INTRODUCTION SiNx

FIG. 16

GAS IRRADIATION SEQUENCE DEPENDENCY AT in-situ POST TREATMENT

GAS	NH_3	H_2
GAS	H_2	NH_3
STEP COVERAGE		
REFRACTIVE INDEX	2.05	2.05

(first GAS row: POSTTREATMENT; second GAS row: PRETREATMENT)

FIG.17

HYDROGEN CONTENT IN Cat-SiN FILM

	Si-H (cm^{-3})	N-H (cm^{-3})	TOTAL-H (cm^{-3})
SINGLE LAYER Cat-SiN	3×10^{21}	4×10^{21}	7×10^{21}
LAMINATED Cat-SiN BY POST TREATMENT IN EVERY UNIT LAYER	2×10^{21}	5×10^{20}	2×10^{21}
PECVD-SiN	6×10^{21}	1×10^{22}	2×10^{22}

500Å-THICKNESS Cat-SiN (100℃)

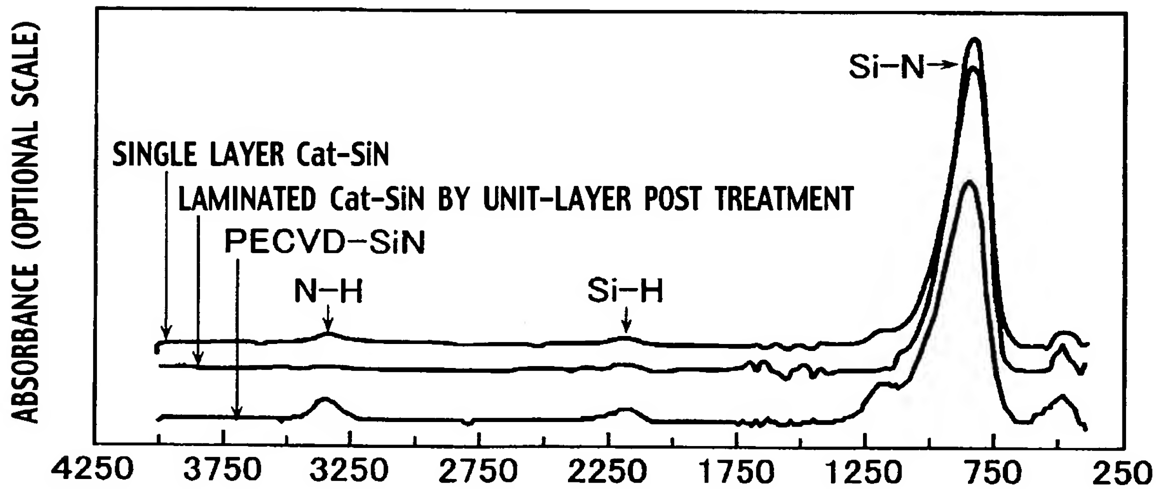


FIG.18

COMPARISON OF HYDROGEN CONTENT OF EACH Cat-SiN FILM

SUPPLY GAS (sccm)			THIN FILM STRUCTURE	Si-H (cm^{-3})	N-H (cm^{-3})	TOTAL-H (cm^{-3})
SiH_4	NH_3	H_2				
7	100	—	SINGLE LAYER	2.4×10^{21}	3.6×10^{21}	6×10^{21}
↑	10	10		1.1×10^{22}	2.3×10^{21}	1.3×10^{22}
↑	100	—	POST TREATMENT IN EVERY UNIT LAYER	1.1×10^{21}	5.7×10^{21}	6.8×10^{21}
↑	10	10		9.2×10^{20}	1.3×10^{21}	2.2×10^{21}

FIG.19

	CONVENTIONAL METHOD	METHOD OF PRESENT INVENTION
SiH_4(sccm)	7	7
NH_3(sccm)	10	10
H_2(sccm)	10	10
PRESSURE (Pa)	10	10
CATALYST BODY TEMPERATURE (°C)	1700	1700
FILM THICKNESS OF ONE-TIME FILM FORMATION (nm)	50	1
NUMBER OF REPETITIONS (TIMES)	1	50
ONE SURFACE TREATING STEP	NONE	H_2
OTHER SURFACE TREATING STEP	NONE	NH_3

FIG.20

	CONVENTIONAL METHOD	METHOD OF PRESENT INVENTION
SiH_4(sccm)	7	7
NH_3(sccm)	10	10
H_2(sccm)	10	10
PRESSURE (Pa)	10	10
CATALYST BODY TEMPERATURE (°C)	1700	1700
FILM THICKNESS OF ONE-TIME FILM FORMATION (nm)	100	1
NUMBER OF REPETITIONS (TIMES)	1	100
ONE SURFACE TREATING STEP	NONE	H_2
OTHER SURFACE TREATING STEP	NONE	NH_3

FIG.21

	CONVENTIONAL METHOD	METHOD OF PRESENT INVENTION
SIDE COVERAGE (%)	70	72
BOTTOM COVERAGE (%)	87	90
I-V WITHSTAND VOLTAGE PROPERTIES (MV/cm)	0.1	4.8

FIG.22

	CONVENTIONAL METHOD	METHOD OF PRESENT INVENTION
SiH_4(sccm)	7	7
NH_3(sccm)	100	10
H_2(sccm)	0	10
PRESSURE (Pa)	10	10
CATALYST BODY TEMPERATURE (°C)	1700	1700
FILM THICKNESS OF ONE-TIME FILM FORMATION (nm)	100	1
NUMBER OF REPETITIONS (TIMES)	1	100
ONE SURFACE TREATING STEP	NONE	H_2
OTHER SURFACE TREATING STEP	NONE	NH_3

FIG.23

	CONVENTIONAL METHOD	METHOD OF PRESENT INVENTION
IN-PLANE UNIFORMITY (±%)	10	4
ETCHING RATE (nm/min)	6	2